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SALT

SALT II: VERIFICATION

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INTRODUCTION

While President Carter and Soviet President Brezhnev were meeting in Vienna on June 15-18, 1979, the Ohio Arms Control Seminar stepped ahead of events to simulate part of the ratification process of the second Strategic Arms Limitation Treaty (SALT II). Sponsored by the Mershon Center's Force and Polity Program, the Ohio Arms Control Seminar (OACS) has grown during its five years of existence to include forty-nine members representing eighteen Ohio educational institutions.

At its annual June meeting, twenty-six members of the seminar staged a condensed version of the hearings on SALT II before a mock Senate Foreign Relations Committee. (A narrative account of the hearings will be published later by the Mershon Center.) The seminar members, other participants from the Arms Control and Disarmament Agency, Harvard's Center for Science and International Affairs, Headquarters U.S. Air Force, and local media representatives uniformly praised the expertise of the witnesses and "senators." Although the seminar members are not by training arms control specialists, they have clearly proved that the intricacies of strategic weapons technology and deterrence theory are learnable.

While recent public opinion polls show that American public awareness of SALT II has risen throughout 1979, there is no complementary evidence that the public grasp of SALT issues has shown increased expertise. Yet, the fate of SALT II will rest at least in part on technical questions that require public education. In no area is this truer than in the area of treaty compliance or verification.

As the members of OACS anticipated, the verification question became a critical question during both the simulated and real Senate hearings. The seminar's concentration on verification profited as well from the concern of Senator John Glenn (Democrat-Ohio), a member of the real Senate Foreign Relations Committee. (Senator Glenn actually attended the simulation and discussed his concerns with the participants.) The burden of defining the verification issue fell to Dr. Thomas W. Milburn, Mershon Professor of Psychology and Public Policy, and his research associate, Mr. Kenneth H. Watman, a doctoral candidate in political science. As the cornerstone of their testimony, Milburn and Watman prepared the following paper, which won uniform praise from all the simulation's participants. It is with great pleasure that the Force and Polity Program now presents this paper to the wider audience it richly deserves.

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At the heart of any international agreement, especially an arms control pact, is the ability of each side to verify the compliance or noncompliance of the other. Without this ability, almost any agreement is bound to collapse under the weight of mutually reinforcing suspicions. Therefore, as the Senate prepares to vote on the proposed SALT II agreement, we are obliged to examine carefully the charges that the Soviet Union will be able to evade SALT's provisions without detection. We will address this question by outlining the fundamental principles of SALT II verification and by looking to the relationship between our technical capabilities and the provisions of the agreement.

The first and most self-evident principle for verification is that we do not trust the Soviets. Indeed, it is precisely because we do not trust them that verification, a substitute for trust, is incorporated in the agreement. So let us put aside this red herring as simply irrelevant to the issues at hand.

The second principle of verification is adequacy. We must make clear precisely what constitutes adequate verification. It is tempting to equate adequacy with our ability to detect and identify the slightest violation of the agreement regardless of how minute or peripheral, but this would be an oversimplification. SALT is an international agreement between sovereign powers for which there is no impartial judge with compulsory jurisdiction over the parties. The purpose of verification is to ensure for us the benefits of SALT that flow from the compliance of both parties, not to win technical, legal points. Verification has no intrinsic value outside the value of SALT itself. Therefore, the test of adequacy is the level of verification that allows us to protect the substance of SALT and to protect ourselves, a quite different matter from our ability to detect every nuance of every action taken by the Soviets that might constitute less than the most precise compliance. This means we must be able to detect a covert Soviet attempt to develop and suddenly deploy new or old weapons in numbers that would be strategically significant. Short of this worst-case situation, our verification abilities must be adequate to detect less drastic though still significant behavior and trends that would indicate a Soviet intention to abandon the restraints of SALT and to provide a timely enough warning that we can react to protect ourselves. This perspective can be abstractly stated as follows: Adequacy is that level of verification which makes the chances of timely discovery high enough to deter a significant violation. We will show that the U.S. means of verification are more than adequate for this purpose.

The third fundamental principle of SALT verification is relevance. By this we mean that, in the context of an arms control agreement, we are not interested in every characteristic of the Soviet strategic forces; not all those characteristics are relevant to the verification of SALT. Rather, we are interested only in those qualities of the Soviet strategic forces that come within the ambit of a provision of the agreement. Therefore, the requirements for SALT verification, both in terms of precision and confidence levels, are less stringent than the requirements of our military intelligence. We believe the issue of relevance is the key to the concerns expressed over the loss of our Iranian monitoring stations. This matter will be explored below in more detail.

The fourth fundamental principle concerns what standard of evidence is required to support a suspicion of violation. Here again, as with adequacy, we must avoid legalisms. We do not require evidence beyond a reasonable doubt. Our evidence can be more realistic; we can act on the basis of a suspicion or on an instance of ambiguous behavior, or merely in reaction to developments in related fields that could tempt

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the Soviets to cheat. Our evidence need not meet the standards of the International Court of Justice, but may rise only to that level which stimulates our sense of uneasiness. We should remember that the Soviet response to our queries is part of the verification process and that it will serve as a basis for inferring Soviet intentions. If the other side is forthcoming about our concerns, we can have greater confidence that the agreement has not been violated. If the Soviets act in such a way as to suggest a violation, we have a number of alternatives open to us. These include the threat of a reciprocal violation of restraints limited to the sector of the observed suspicious behavior; a demand for immediate rectification or, in the alternative, a showing of our mistake; a consultation to reduce the ambiguities; or a warning that we are alerted and sensitive to further hints of noncompliance.

We believe the U.S. system of verification more than satisfies the requirements set by these four fundamental principles. But the process of detection, of course, rests on our technical ability to discover what is transpiring covertly on the other side. It is these technical factors and their relationship to the terms of the agreement that we now consider.

Sensor Technology

This description of sensor technology applies to both aircraft and satellite reconnaissance. Although a designer of sensors might wish to monitor a broad electromagnetic spectrum, he is actually restricted to just a few frequency ranges.

1. The high-energy radiation in the X-ray and gamma-ray regions is of limited use because sources of this radiation are not connected with activities on earth relevant to SALT. However, they are used to detect nuclear explosions in space.

2. The ultraviolet region is useful for observing the earth's ionosphere since atmospheric nuclear explosions and missile launchings disturb the ultraviolet characteristics of the upper atmosphere. Indeed, each type of explosion and missile leaves particular and distinctive ultraviolet signatures which can be used to identify the source of the disturbance. The ultraviolet frequencies cannot be used to observe the earth from space since the atmosphere severely attenuates radiation in this range.

3. The visible spectrum is the electromagnetic region of human vision and provides a wide window for observing the earth. Without going into great detail about such things as focal length and film emulsions, let us say that the new generation of observation satellites, Big Bird and the KH-11, can approach the atmospheric limit on ground resolution of six inches to 1 foot from a distance of 100 miles. It must be said that this level of resolution is usually degraded somewhat by atmospheric turbulence and cloud cover. Other areas of the electromagnetic spectrum are not affected by these problems, as we will relate, and so compensate for the loss of visible-light acuity. Television, film, and digital methods are used to transmit visible-light data. Television has the advantage of providing real-time reconnaissance but its resolution is somewhat less than what is possible with film. Film, however, must be recovered from the satellites and processed so there is an inevitable time lag between reconnaissance and interpretation. The digital transmissions are of a slightly lower resolution than film but are instantaneous like television. Much progress has been made with low-light technology so that photography of high resolution is possible under moonlight, twilight, or even starlight.

4. All objects with temperatures above absolute zero emit electromagnetic radiation continuously. At temperatures below 500° F, most of this natural radiation falls in the infrared portion of the spectrum. A wide assortment of films, lenses, and television tubes have been developed in recognition of this fact. Infrared reconnaissance has two distinct advantages over visible light: It can be used at night and, because infrared radiation is emitted by objects and not reflected, it can penetrate camouflage or earth. The price paid is that the resolution of infrared optics is approximately an order of magnitude less than that for visible light. Short and long wavelength infrared sensors are carried on early warning satellites to detect the hot gas plume emitted by missile launchings. These sensors are also carried by observation satellites to detect underground missile silos, penetrate camouflage, and track missiles in mid-course in both day and night.

5. Unlike visible light and infrared, radar has all-weather capabilities. In the past, this type of sensor has suffered both from the need for very large antennae and the problems of atmospheric attenuation. However, the side-looking radars installed on observation satellites can now produce high resolution images by exploiting the motion of the vehicle to make a small antenna perform like a large one.

6. Radio frequency sensors are also used by the new generation of Rhyolite satellites to intercept ICBM telemetry.

The technical abilities of U.S. sensor technology are important. But equally important is to keep in mind the redundancy and complementarity of each of these methods of remote sensing. Each has weaknesses and strengths which interact synergistically to make systematic evasion extremely difficult.

Observation Satellites

Observation satellites have two major tasks: area surveillance and close-look. The area surveillance involves the surveying of very wide areas (all of the Soviet Union or China) with sensors of moderate resolution. Those data are then quickly transmitted to earth so that particular areas of interest can be identified and high resolution, close-look photographs taken from a lower orbit. The area surveillance data are usually transmitted electronically; close-look films are sent back to earth in reentry capsules which are recovered in mid-air by specially equipped aircraft.

During the 1960s and early 1970s, the United States had to use two separate types of satellites to carry out the two tasks. However, since June 1971, an entirely new fourth generation of observation satellites, the Big Bird type, has been introduced to perform both missions. This series carries both area surveillance and close-look visible-light cameras, an infrared optical system, side-looking radar, and multi-spectral sensors. In addition, Big Bird is equipped with a television camera with a zoom-type telephoto lens which transmits real-time images to earth via synchronous communications satellites. Big Bird has the ability to change its orbit to conduct the area surveillance and close-look missions and can maneuver to take advantage of breaks in cloud cover. In the last 18 months, Big Bird has begun to be replaced by a fifth generation of observation satellites, the KH-11 series, carrying even more sensitive sensors and more efficient methods of information transmission.

In the context of SALT, the observation satellites are best suited for verifying quantitative provisions. From satellite pictures analysts can detect new silo construction and missiles being transported to their deployment sites. Multispectral and infrared photography enable us to detect and penetrate camouflage and to monitor nighttime activities. Submarine construction yards can be kept under constant observation and a count kept of the submarines. Above all, observation satellites provide timely warning of activity in violation of SALT by monitoring Soviet transportation networks, manufacturing facilities, and power generation without which it is impossible for modern strategic systems to be constructed and tested. The real-time reconnaissance capability of both Big Bird and the KH-11 allows analysts to closely examine suspicious activity. While photography cannot penetrate buildings, infrared and multispectral techniques can reveal an extraordinary amount of inside activity. More important, even when the nature of inside developments remains ambiguous, the sensors can tell analysts that something of concern might be happening. This will enable U.S. political authorities to pursue the matter with the Soviets at the SCC. So, even when the cameras do not penetrate a deception they will inform us that an effort to deceive is taking place and will provide enough basis for a query. Cloud cover has been a problem in the past, but the side-looking radars now deployed have sufficient resolution to reduce the ambiguity caused by clouds. Other methods of intelligence supplementing the observational techniques are discussed below.

Surveillance of Missile Tests

The ability to monitor Soviet missile tests is particularly important in verifying qualitative provisions of SALT. Therefore, we will not discuss the monitoring systems solely concerned with war-fighting, such as the DEW line, Semi-Automatic Ground Environment Back Up Interceptor Control, and AWACS.

1. Line-of-sight radars have been stationed in Turkey and Iran to track Soviet missile tests emanating from Kapustin Yar and Tyuratam. In order to track the Soviet vehicles along the length of the test track, radars of great range and precision have been deployed at Shemya, Alaska in the Aleutian Islands, Johnston Island, Midway Island, Kwajalein Atoll, and Bikini Atoll. In addition, radar picket ships and aircraft are deployed to cover the target areas both in the Pacific and Soviet Kamchatka. These radars provide the following sorts of data: First, they can detect the existence of a test. Second, the trajectory of the test vehicle can be determined and, from that determination, the range and region of impact can be inferred. Third, the size and shape of the missile and reentry vehicle can be determined based on flight path characteristics and acceleration. Fourth, new missiles can be detected since every missile currently deployed has a unique radar signature. Fifth, the sequence and frequency of the tests allow us to monitor the progression through the development, test, and deployment cycle of a new weapons system. Certain other important information is available only to line-of-sight radar. Such data as the detailed structure of the reentry vehicle, its ballistic coefficient, and degree of maneuverability are collected from sensors located close to the final impact area. These sensors will be discussed below.

2. Unlike line-of-sight radars, over-the-horizon radars are not constrained by the curvature of the earth. By reflecting off the ionosphere, OTH radars can penetrate to great distances. The back-scatter variety of OTH uses the Doppler characteristics of a signal reflected by a missile to determine its velocity and acceleration. The forward-scatter variety detects disturbances in the ionosphere caused by the ionized jet of gas emitted from rocket engines. Since each type of missile disturbs the upper atmosphere differently, forward-scatter OTH can be used to identify a missile by its signature. Of particular interest is the forward-scatter OTH called System 440-L deployed in the Far East and Western Europe. Although the radar was designed as an early warning system, it has also detected an extremely high percentage of Soviet and Chinese missile tests.

3. Like the OTH radars, satellite systems that were developed to provide early warning of an attack also detect and track missile tests. These satellites are equipped with short-wave infrared telescopes and receivers to detect the exhaust plumes of missiles lifting off, and to pick them up as they emerge from the earth's atmosphere. To reduce the danger of false alarms, a television camera is also carried which is automatically directed at any suspicious infrared source. The images are then transmitted in real-time enabling observers to see the object. Once the reentry vehicle separates from the missile, long-wave infrared sensors mounted on aircraft and ships take over to provide accurate trajectory and warhead data.

4. The most accurate information about reentry vehicles comes from shipboard sensors located close to the impact area. These radar and infrared devices can detect MIRV testing, the weight and ballistic coefficient of the warhead, and improvements in accuracy.

5. Last year a new type of satellite, the Rhyolite series, was placed in geostationary orbit in order to intercept missile telemetry from Soviet tests. So far, four of these satellites have been deployed to intercept data from the liquid fuel ICBM tests at Tyuratam and the solid fuel ICBM tests at Plesetsk. Telemetry data are used to help determine characteristics of the test missiles. For example, fuel flow data contained in telemetry are one way of calculating range, throw weight, and launch weight.

It is a happy consequence of the complexity of strategic systems that very extensive and elaborate testing must precede deployment. This testing is lengthy and highly visible, as are efforts to conceal it. Therefore, the ability to observe these tests is an integral part of arms control, especially qualitative limits. The visiblity of the tests discourages the development of systems that would violate the agreement. In the event the Soviets are not discouraged, length of the testing period ensures a timely warning for us. In more detail, the U.S. monitoring capabilities enable us to detect the following qualitative improvements: First, new boosters can be identified by their characteristic signatures as observed by line-of-sight (minus Iran) and OTH radars in conjunction with infrared sensors on early-warning satellites. Second, any appreciable change in the front end of the missile or the reentry vehicle can be detected by the down-range sensors.

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Third, since significant changes in accuracy must be associated with structural changes, important CEP improvements can be detected. Fourth, the presence of maneuvering warheads can easily be detected. Fifth, MIRV testing can be detected by the land-based and ship-borne radars as well as by satellite systems which can observe the MIRV bus. The number of warheads can be directly sensed with radars and also inferred from the movements of the bus.

Verification of Specific SALT Provisions

The new SALT treaty consists of quantitative and qualitative restrictions which the Soviets could try to evade in three ways: First, they could deploy new types of strategic weapons. Second, they could deploy more weapons of an existing type. Third, they could change an existing system so that its capabilities are increased or changed in a way relevant to SALT. Let us consider the verifiability of SALT, provision by provision.

1. Combined strategic nuclear delivery vehicles (heavy bombers, SLBMs, ICBMs, and air-to-surface ballistic missiles) are to be limited to 2250 by 1982. The first method of cheating, the deployment of new systems, entails a five-stage process: research, development, testing, production, and deployment. The U.S. has a fair to excellent ability to detect covert activity in all but the first of these stages. This means that the Soviets have to conceal successfully all four of the latter stages. A moment's reflection will show that, even in a worst-case situation in which the U.S. ability to detect cheating is .5 (it is much better than .5, in fact), the chances of all four stages escaping detection are .06. When one considers that a major weapons program requires approximately a minimum of ten years from R & D to deployment, it is clear that the probabilities of a timely warning are exceedingly high. Weapons development takes place at a relatively few centers in the Soviet Union, much as in the United States. These are closely observed, and the flows of tell-tale materials can be monitored. Any weapon prototype has to be transported to the test sites (which are known) and this movement is easily detected as are the extensive preparations and radio traffic at the sites. New weapons require extensive tests for long, visible periods. Production of sophisticated systems is concentrated at only a few places. Finally, deployment is easily observed and there is a long time-period between the beginning of deployment and the point at which a new system becomes operational. Different weapons are most visible at different stages. Submarine construction, for example, takes place at a few yards in the open. Therefore, submarines are most easily detected at the development and production stages. But even at the testing stage, a craft with new performance is detectable by U.S. naval units. Tests are especially open to detection in several ways. U.S. line-of-sight radars produce distinctive signatures of reflected microwaves from each major type of Soviet missile. A new type of missile produces a new signature. Similarly, OTH front-scatter radars can detect and recognize the characteristic pattern each type of missile makes as it passes through the upper atmosphere. Early warning satellites carrying infrared sensors can identify the exhaust plumes produced by test firings. Finally, as indicated above, the United States has a complex assortment of sensors to monitor the length of the trajectory including the impact area. Likewise, development, testing, and production of new heavy bombers is highly visible. Therefore, the likelihood of the Soviets violating the 2250 limit by introducing new systems covertly is nil.

What about the deployment of old weapons of an existing type? As pointed out above, the production and deployment of major weapons, even existing ones, is a highly complex and visible procedure. Material has to be transported, command and control facilities have to be built, new holes have to be dug just to mention a few of the required actions. Attempts at camouflage can be detected by infrared and multispectral sensors. It is true that the probability of detection varies directly with the size of the violation. Therefore, it is possible that very small-scale violations could escape the verification net. To be conservative, let us say 100 ICBMs of an existing type could be deployed covertly.

Missile submarines are large vessels displacing up to 9,000 tons and measuring more than 300 feet. Their construction sites are known and under constant observation and, since SALT I, the construction itself has been in the open. Even if the Soviets were able to build submarines covertly, the vessels eventually will have to be moved from the shipyard. From that point on, there are innumerable opportunities for detection, and the chance of a significant undetected increase in the Soviet missile submarine force is nil. The same is true for the deployment of additional submarine missiles.

An increase in the number of heavy bombers is equally subject to detection. The production lines of the Bear and Bison strategic bombers have long been closed and their restart would be readily discernible. The production facilities for the Backfire are monitored and an increased rate of manufacture would be quickly detected. Beyond that, the deployment of additional units would be very hard to hide. Large planes are not easily handled or serviced. New hangars, facilities, and long runways would have to be built and these would be virtually impossible to hide.

Last, what are the prospects of the Soviets converting existing systems in a way that would violate the strategic launcher limit? This is a somewhat more challenging problem since two Soviet systems, the SS-20 IRBM and the Backfire, could be made into strategic weapons. The two-stage SS-20 is an intermediate-range missile and as such is not covered by the strategic launcher provision. However, verification is complicated because the SS-20 simply comprises the first two stages of the three-stage SS-16, an ICBM. Furthermore, the mobile launcher for the SS-20 is identical to that for the SS-16. It is feared that the Soviets could covertly stockpile SS-16 third stages posing the threat that many SS-20s could suddenly be transformed into ICBMs. This has been obviated by the Soviet agreement not to produce, test, or deploy the SS-16. The SS-16 has been plagued by problems; its last tests were several years ago and all were failures. If the Soviets were to pursue the third-stage stockpiling deception, they would have to be willing to rely on a virtually untested system with no record of success. We believe the likelihood of this course to be nil.

The Backfire bomber in its present configuration has a limited intercontinental capability; it can fly one-way missions to the United States. Round-trip strategic missions would require either tanker refueling or a change in the bomber's configuration. The Soviets have committed themselves to inhibiting the Backfire's use as a strategic weapon.

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These commitments have the same binding force as the corpus of the agreement and are expected to limit Backfire production, deployment, and refueling capability. As indicated above, production and deployment are easily verified. The tanker restrictions are predicated on the difficulty of mid-air refueling and the amount of practice and training required to develop confidence in the procedure. Practice runs can be monitored in several ways including ELINT and COMINT. The Soviets are faced with attempting wartime refueling without practice if they want to avoid U.S. observation. Verifying the range configuration of the Backfire is quite difficult and skillful camouflage would probably enable configuration changes to evade detection. The restriction in Backfire production is to compensate for this.

2. Of the 2250 permitted strategic nuclear vehicles, neither side is allowed more than a combined total of 1320 of the following types: launchers of MIRVed ICBMs, launchers of MIRVed SLBMs, heavy bombers equipped for long-range cruise missiles, and MIRVed ASBMs. Of the 1320, neither side is permitted more than a combined total of 1200 launchers of MIRVed ICBMs, launchers of MIRVed SLBMs, and MIRVed ASBMs. Of the 1200, neither side is permitted more than 820 launchers of MIRVed ICBMs.

There are four ways the Soviets could try to evade the MIRV/ALCM limit, all falling into the second category of cheating: deploying more weapons of existing types.

First, the Soviets could build more submarine missile tubes or landbased missile silos to accommodate more MIRVed missiles. As indicated earlier, either of these two courses is readily observed.

Second, the Soviets could try to substitute MIRVed for unMIRVed missiles. This possibility exists because the Soviets have a number of unMIRVed missile types and silo fields containing unMIRVed missiles. This is also true for some Soviet missile submarines. Detection depends upon our ability to know which missiles are MIRVed and which silos contain them. This is precisely the rationale for the counting rules upon which the United States has insisted. Both sides have agreed that if a missile type has been tested in a MIRVed mode, all missiles of that type will be counted as MIRVed. But, would it be possible for the Soviets to substitute covertly MIRVed for unMIRVed missiles in existing silos? The answer is "no" because of the known dimensions of the missiles and the requirements for MIRVing. Silos that contain missile types counted as MIRVs under the rules look significantly different from silos that do not. Further, silos containing MIRVed missiles require clearly different command-and-control facilities which are easily detected. All of these constraints are equally true of submarine missile tubes.

Third, the Soviets could try to evade the limit by surreptitiously substituting MIRVed for unMIRVed warheads or by increasing the number of MIRVs on existing MIRVed warheads. As with some of the other items, this method of cheating depends upon the Soviets' willingness to rely on untested systems. Substituting a MIRVed for an unMIRVed warhead or increasing the MIRV number completely alters the flight characteristics of the warhead and the missile. At intercontinental ranges, small errors have very great consequences. Further, these alterations cannot be accurately predicted by simulation. Therefore, a program of testing is required for all such changes and MIRV testing is open to easy detection. For these reasons, the MIRV counting rules limiting the SS-18 to ten MIRVs, the SS-19 to six MIRVs, the SS-17 to four MIRVs, all SLBMs to 14 MIRVs, and all new ICBMs to ten MIRVs are verifiable.

Fourth, the Soviets could try to cheat by placing more ALCMs on their bombers than permitted. The arithmetic of the sublimits allows either side to deploy up to 120 heavy bombers armed with ALCMs. The average number of ALCMs per new bomber must equal 28, the average number per existing bomber must equal 20. These conditions heavily favor the United States since the Soviets lag behind us in ALCM development, but assume for the sake of argument that they do not. The Soviets have never mounted cruise missiles internally; they are all externally mounted and visible. Installation of internal launchers would be a major effort, probably requiring the flight of eligible bombers to central facilities for conversion. The United States monitors such activity quite closely. In addition, the dimensions of the Soviet ALCM are different from those of gravity bombs, so the bomb bay doors would have to be altered for internal mounting and this is detectable. More difficult to verify is the payload of ALCMs. It is not possible to distinguish between an ALCM carrying a nuclear warhead and one that is not, at least not by external observation. Again, this is really the Soviets' problem rather than ours since they are not expected to have precision-guided ALCMs (nuclear or nonnuclear) for the duration of the treaty.

5. In exchange for the ALCM provisions, the treaty allows the Soviets 308 modern large ballistic missiles. MLBM is defined as any missile larger than the SS-19 (8,000 tons) with an upper limit of the size of the SS-18 (16,000 tons). As indicated above, the U.S. capability to monitor Soviet testing enables us to determine with great accuracy the SALT-related characteristics of a missile. In addition, deployment of a missile violation of the MLBM limit would be easy to observe as evidenced by the SALT I debate over the substitution of the SS-11 with the SS-19.

6. The treaty bans rapid reload systems for both sides. This can easily be verified both directly and indirectly. Directly, loading a large missile weighing many tons with reliability requires elaborate, visible equipment near the silos. Indirectly, additional missiles have to be stored quite near to the silo fields to make the reload rapid. They have to be transported to the area and sheltered there. Such activities are very difficult to conceal.

The protocol contains several temporary prohibitions to remain in force through 1981.

1. Both sides are prohibited from testing and deployment of new types of ICBMs with the exception of one new ICBM for each side. Newness is defined as five percent difference in volume or performance between the new missile and the Minuteman III or the SS-19 with a ceiling of the

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SS-18. This provision can be verified through our ability to monitor the tests of Soviet missiles and, from those tests, to infer missile characteristics.

2. Both sides are prohibited from deploying and testing mobile ICBM launchers. Such activities are highly visible and easily verified. One possible ambiguity is the SS-20 IRBM mobile launcher which is identical to the SS-16 ICBM launcher. This problem is resolved in the same way the third-stage problem was: The SS-20 mobile launcher is no strategic threat if the SS-16 ICBM cannot be used.

3. GLCMs and SLCMs are limited to a range of 600 kilometers. Again, this is much more a problem for the Soviets than for us since they are approximately ten years behind in cruise missile development. The ranges of cruise missiles cannot be verified because, unlike other strategic missiles, cruise missiles need not be tested at even near full range for the military to have confidence in its performance. The United States is in the midst of flight testing highly advanced, compact cruise missiles and these are not scheduled for significant deployment until after the protocol expires. The Soviets have not reached even this stage, so it is difficult to see how the problems of SLCM and GLCM range verification threaten the advantages of SALT II for the United States.

It has been emphasized that the United States has many overlapping, redundant means of checking Soviet compliance with the SALT II treaty. Given the costs to the Soviet Union of being detected in a clandestine strategic weapons development prohibited by SALT II—ranging from curtailment of trade and technical aid to a vast increase in the arms race or total U.S. abrogation of the treaty—what is the likelihood of such a violation? In general, the more effective the verification, the less likely it is to be needed because increased probability of discovery of forbidden activities increases the risk and subsequent costs of violations. Studies of past Soviet risk-taking behavior appear more relevant than doctrine-based assertions about Soviet motives either to defend against invasion or to dominate the world. Such is the case because opposite motives can lead to the same behavior. A preemptive military strike, for example, is ambiguous in that it may serve defensive or offensive ends. The Soviets have recently been responsive and cautious: U.S. responses to Soviet actions that might have constituted violations of SALT I led either to Soviet explanations the United States found satisfactory or to cessation of the behavior in question. Moreover, assessment of Soviet risk-taking behavior over a number of historical cases has led U.S. scholars ranging in ideology from moderate to right-wing to conclude that the Soviets are cautious, conservative risk-takers. The Soviet military establishments in particular have preferred to advance only under conditions of the most favorable odds, the better to absorb the inevitable uncertainties associated with military engagements. The immense size of the stakes in Soviet-U.S. relations would appear to increase Soviet cautiousness and perhaps to decrease the probability of attempts to violate the agreement that representatives of both nations have signed.

In summary, all strategic systems are highly complex and react in nonpredictable ways to engineering changes. To employ missiles with any degree of confidence, extensive testing, i.e., ten to thirty tests, is necessary, and extensive testing tends to be highly visible. In interpreting actions of the Soviet Union the United States is interested in patterns and trends as contrasted with isolated events. The confidence level necessary to rely upon a strategic weapons system is quite high for both the United States and the Soviet Union, and the Soviets have shown themselves to be cautious, low risk-takers in situations of importance to them, e.g., national security. SALT II, of course, is a matter of relevance to the national security of both nations. ■